special codes for automatic chapter stops, if any. This is usually done at the mastering studio according to directions from the client.

Since videodisc mastering and replication is expensive, it is important that the final master tape or film be carefully reviewed prior to mastering so that any errors may be corrected at that time. If no such checking procedure is possible, then the tape must be mastered onto disc and one or more replicates produced for review purposes. If errors and then discovered, the entire mastering and replication procedures must be repeated, adding expense to the disc production.

The output of post-production on videotape is a 1" or 2" master tape, ready to go to the mastering studio. The digital magnetically stored computer program is ready for duplication on 2 other magnetic discs as soon as the disc is mastered and videodisc frame numbers are known (they are not the same as the SMPTE code numbers). In the future the programs will be mastered onto the videodisc itself .

Post-production need not be close to other components. Post-production requires broadcast quality tape players, either 2" or 1", mixers and switchers to mix video and audio inputs and to switch between video inputs in editing a master tape, and some kind of editing console, often computer controlled, that controls the edits that are made in the production of a master tape. Some studios also have film chains and Slo-Mo discs available.

It is possible to tie a video/character generator directly into the editor. Text frames could thus be edited directly from the character/graphics generator onto the master tape. This implies, of course, that either the text frames were originally created in the studio on that character/graphics generator itself, or the frames were created on an identical character/graphics generator off-site. It is possible to use an off-site character/graphics generator to create and store the frames on a magnetic disc and then to carry the disc to the studio to be read by the character/graphics generator there.

Mastering and Replication

Optical videodisc mastering is a central manufacturing operation in which the master tape controls a laser which etches a photo resist covered glass plate. The plate is then used to create stampers. During replication, the stampers create plastic replicates which are given a protective coating (depending on the manufacturer) and distributed.

Summary: Three Levels of VAP Systems

The above alternatives provide a large number of possibilities for authoring and production systems. From these, three systems have been chosen to exemplify the choices.

Level 1. At this level, authors produce the instructional program in manuscript form using paper authoring guides. They receive back a 3/4" tape with visual SMPTE code and still frames repeated for at least one second. The authors review this tape, and write out in longhand the edit sequence, which then guides the post-production technicians who make the final edit. Since there is no computer control of the 3/4" tape player, branching can be laborious. This level is not well suited to the intelligent videodisc.

Level 2. At this level authors can choose to input their text directly at a computer authoring station or they can give the text entry to a packager (a specially trained typist). The authoring station includes a text editor and author prompting, and uses a high resolution CRT. The text portions of the program must be converted to NTSC standard video using a separate character generator.

Level 3. This level permits the author or packager to use a computerized authoring station with an integral television character generator, so that the author sees just what the student will see. No transformations are required for the text. Editing utilizes a computer-controlled videotape player. The computer program not only drives the player, but also keeps track of the edit sequence and produces a machine-readable edit list. This edit list drives the post-production studio's computer editor.

These three levels portray from the author's viewpoint, the kind of systems which are likely to emerge.

Film-Based Videodisc Authoring and Production Systems

This section briefly presents the major steps in film-based videodisc production in terms of changes or differences with tape production. For the reasons detailed above, film is not a particularly easy medium to use for videodisc work.

Mendenhall (1979) presents a more technical discussion of some of the production alternatives described here. The paper covers both tape- and film-based production systems, but emphasizes manual videodisc VAPS. It includes estimated costs.

Authoring. Text is prepared as described for videotape. If existing film is used, a good source outside the Army is Encyclovideo. This is a computer index of video clips from Encyclopedia Brittanica films, which cost $216 per minute when used for national distribution.

Media Production. Figure 14 presented the media flow chart for film. Since film will eventually be transferred to videotape for videodisc mastering, some extra planning is necessary. Stills must be shot using the television aspect ratio and safe title area (the area in the center of the screen where even poorly tuned receivers will be relatively sharp). High quality film should be used (either 35mm of 16mm Xenon-base film) to maintain image resolution and to limit the color noise caused by film graininess. Likewise developing and printing should be handled by a top quality lab to minimize color shifts between batches. If slides are used, they should be in pin-registered mounts to limit their shifting and misalignment with other text or graphics.

Media Transfers. During the media transfer step the following occur: (a) existing or new film must be copied and divided into A and B rolls for edit, (b) board art and typeset text must be transferred to Kodalith copies, the background color and highlighting added, overlays burned through, and the final slide made, and (c) character generator screen images must be transferred to slides. Usually a production group would need to make some but not all of these transfers.

Off-Line Edits and Tryouts. Slide editing is simply a matter of rearranging slide sequences and motion sequences off-line (i.e., without an expensive flat bed) and is best done with a slide projector, a still frame film projector and a splicer, using copies of the original films so that the originals will not be scratched. During tryouts the slides can be easily accessed so long as the computer branching stays within an 80 frame limit (the capacity of the slide tray on a standard Kodak RA960 random access projector). Beyond that, some tray changing is required. Motion sequences on roll film cannot be randomly accessed, but can be placed in a rough order and on several reels to facilitate searching the film during tryouts. The edit list for film is in terms of feet and frames for motion segments and slide numbers for stills. The list guides final editing at the studio.

Errors in technical production or in content should be revised before post-production. It is reasonable to assume that each manually-produced text frame will be redone once, and each text with graphics overlay will be redone twice, on the average.

Post Production. As with tape, post production is best done using professional equipment to handle audio and film editing. Slides are transferred to roll film using an optical printer, then the motion sequences on A and B rolls are combined with the still frames on a C roll to produce the final film. The audio is edited separately, then the visuals and audio are synced. At the completion of the edit, a copy of the original should be made for review.

Review. During review with film, it is possible to examine motion sequences and individual still frames, but not to observe the effects of branching, since random access is not readily available.

NEW HARDWARE AND SOFTWARE NEEDED

In the course of preparing videotape material for disc mastering, reviews and tryouts will be conducted using still frames and random access. It is possible to use off-the-shelf 3/4" videotape players to review still frames by repeating the frames a number of times on the tape so that an operator can stop on one of the duplicates within the accuracy of the player (typically 3 to 15 frames). However such repetition is not possible on the final tape, where still frames occur only once. The final review, then, may be conducted either on a 1" helical scan studio tape machine or on a modified 3/4" player which is single frame accurate.

Tryouts using the random access feature will be clumsy and slow if much hand manipulation is required. If magnetic disk-stored digital text is used for tryouts, the problem will be less severe because the mag disk provides random access. However, if the text is stored on videotape, a frame-accurate, computer-controlled random access 3/4" videotape player will greatly facilitate tryouts. Prototype versions have already been constructed, both by University and Commercial R & D groups. This and other alternatives for videotape review and tryouts will be explored the second year.

As part of the authoring system for this project, a number of software features need to be developed. These include the following:

1. A management and tracking system to permit recording, prediction, and control of each item as it passes through the production process.

   The system might include some of the features of the Defense Advanced Research Projects Agency (DARPA) Author Management System (O'Neal and O'Neal, in press). Each lesson is tracked through the production process, so that the manager can predict its completion, review and tryout dates, and can allocate personnel accordingly. The version used on this project should initially be paper and pencil while it is being tested.

2. Author prompting and editing software for developing videodisc instruction, as described in the section on authoring. The same system can be used by the packagers.

3. An intelligent videodisc symbolic-address system, so that arbitrary frame numbers can be used in authoring and production, then converted to absolute videodisc frame numbers after mastering, when actual frame numbers become known.

4. An edit control file program which produces computer-readable output to run the computer video editor.

5. Formative evaluation software to record and analyze student responses and paths through the curriculum.

CONCLUSION

Videodisc training delivery systems (VTDS) have a substantial and important potential for use in Army training. There is a variety of systems ranging from the inexpensive manual videodisc to the second-generation intelligent videodisc system. With increased capabilities comes increased complexity and difficulty in Instructional Systems Development (ISD) for VTD systems. The same ISD procedures may not be applicable for all types of VTD systems.

It is important to recognize the diverse capabilities in Army TASO's especially the diversity of available equipment at these and other locations where videodisc authoring will be done in the future. These constraints were discussed in Part II. It is also important to recognize that microcomputer and videodisc technologies are evolving rapidly. These rapid developments in technology, coupled with the diversity at Army authoring sites, makes it inadvisable to propose a single videodisc authoring and production system (VAPS). It was concluded that the original conception of a single author mock-up system conceived at the beginning of this project does not appear viable in light of the diversity of existing hardware at Army authoring sites, and rapid technological change.

Instead of a single VAPS hardware configuration, a range of complexity in VAP systems ranging from simple and inexpensive to complex and computer-controlled was presented herein. It was concluded that ISD procedures can be made applicable for the variety of VAPS equipment configurations that will exist as the Army begins serious videodisc authoring. Indeed, it is necessary that they be made applicable.

The procedures presented in Part II in connection with the range of VAP systems represent in actuality a detailed modification to Phase III, block 4 "DEVELOP" of the Interservice Procedures for Instructional Systems Development (TRADOC 350-30). These procedures will be evaluated by using them in the production of Army videodisc materials, for administration on a "brassboard" intelligent videodisc system during the second year of this project.

Technological development is needed, both in the areas of hardware (both VTDS and VAPS systems) and software. The PLANIT software package as it stands is a good vehicle for testing the proposed ISD procedures for videodisc development and for delivering the completed packages. However, there are software enhancements for both the delivery of interactive videodisc programs and the authoring of programs for a range of VTD systems that could improve the cost-effectiveness

of ISD and instructional delivery. These software enhancements are described in both Part I and Part II.

This volume serves as a basis for the detailed discussion of videodisc ISD in Volume II of this annual report and for the discussion of graphics usage with VTD systems that is found in Volume III.

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FOREWORD

The Manpower and Educational Systems Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) performs research and development in the area of educational technology with application to military training. Computer-based training systems have been an area of particular interest. Developing and implementing such systems has the potential for reducing both training time and cost while, at the same time, providing more individualization than is possible using conventional training methods.

This report is Volume I of a three volume report on an Instructional Systems Development (ISD) Model for Videodisc Training Delivery Systems with Interactive Capability. A model instructional delivery system is being developed in order to bridge existing technological gaps. This effort called for identifying preliminary on and off-line techniques, key requirements and aids for an integrated microprocessor - controlled videodisc system, and relating these requirements, etc., to the prototype ISD model. Also included were the development of a preliminary testable set of principles and guidelines concerning when, where, what kind, and how much graphics to use in select videodisc settings.

The entire research work unit was initiated during FY 1977 in response to the requirements of RDT&E Project 2Q161102B74F (Research in the Behavioral and Social Sciences) and 2Q162722A764 (Education and Training). The research was performed in support of the FY 77 ARI Work Program under Project A764, Theme 4: "Videodisc Technology Applications to Battle Simulation Devices," and A764, Task A, Work Unit 2, "Critical Factors in the Optimization of Device/Media Selection and Evaluation."

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With the award of this contract to WICAT Inc., a professionally satisfying and highly productive association began between key ARI and WICAT personnel. The work was originally monitored and supported by Dr. John E. Germas and Mr. John Larson until the untimely death of Dr. Germas in 1979. At that time Dr. Leon Nawrocki assumed management responsibility for the effort. The WICAT Inc. team included Dr. C. Victor Bunderson, Dr. J. Olin Campbell, Steven Booth, Dr. James Schuyler, Dr. Dustin Heuston, Robert Mendenhall, and other WICAT personnel.

Special thanks are due to Dr. Paul Merrill, who spearheaded the Volume III report, Dr. Joseph Lipson, who consulted on the Volume III report, Dr. Charles Frye, who consulted on the implementation of PLANIT and provided extremely valuable assistance. Mr. Jack Calloway provided valuable consultation in video production techniques.

Thanks are due to many industry representatives in the computer, video, and videodisc industries who were consulted in obtaining the data in this report. These companies and some of the helpful individuals are mentioned in the methods section.

The conclusions and recommendations of this study are those of the authors. They should not be construed as an official Department of the Army position or policy.

This report is dedicated to Jack Germas.